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(54) METHOD AND APPARATUS FOR PREPARING FOAMED SYNTHETIC RESIN INSULATED WIRING

(71) We, NIPPON TELEGRAPH AND TELEPHONE PUBLIC CORPORATION, a Japanese corporate body, of 1-1-6, Uchisaiwai-cho, Chiyodaku - Tokyo, Japan, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to the manufacture of electric wiring insulated with foamed synthetic resins.

The invention comprises a method for preparing foamed synthetic resin insulated wiring which comprises supplying a thermoplastic synthetic resin and normally gaseous hydrocarbon soluble therein to an extruder in an atmosphere of said hydrocarbon which is at a pressure large compared with normal atmospheric pressure, heating, melting and mixing the charged materials in the extruder, and extruding the molten resin in which the hydrocarbon is uniformly dissolved, thereby to coat the surface of electric wiring with a foamed synthetic resin.

The invention also comprises an apparatus for preparing foamed synthetic resin insulated wiring which comprises an extruder consisting of a screw section, a driving source for driving the screw of said screw section and a cross-head directly connected to said screw section and containing a die, means for introducing a thermoplastic synthetic resin and a hydrocarbon into the extruder at a pressure large compared with normal atmospheric pressure under a condition shut off from the open air, and means for feeding electric wiring to the die of the extruder.

Use of the method described herein enables a large amount of hydrocarbon to be dissolved in a molten mass of synthetic resin and electric wiring to be manufactured in a form insulated with a coating of a foamed body containing fine, uniform, separate cells, wherein pin holes are less likely to occur. More particularly, electric wiring can be manufactured which is insulated with a coating of a highly expanded body of about 100 to 300 microns in thickness and of fine cell size less than 30 microns in diameter. It is also possible easily to control the degree of expansion of a foamed insulation coating by changing the amount of hydrocarbons supplied, the extruding conditions and, if required, conditions for auxiliary thermal forming, such as cooling, heating or a combination thereof, which may be carried out after extrusion and coating.

The single Figure of the appended drawing represents an apparatus embodying the present invention.

In one embodiment of the present invention, pellets or powders of a thermoplastic synthetic resin and normally gaseous hydrocarbon soluble therein, having a lower boiling point than the melting temperature of the resin, are simultaneously supplied in an atmosphere of the hydrocarbon which is at a pressure large compared with normal atmospheric pressure to an extruder for coating electric wiring through a pressure-resistant intermittent raw material feed apparatus at a temperature not higher than the melting temperature of the resin, partly melting the synthetic resin in a first low temperature region of the extruder to occlude the hydrocarbon therein, completely melting the hydrocarbon-carrying resin in second higher temperature regions of the extruder for solution of the hydrocarbon therein, and extruding the molten resin containing the dissolved hydrocarbon on electric wiring to be coated to form a foamed coating.

The thermoplastic synthetic resin used in the present invention generally consists of polyolefins, for example, polyethylene, polyisobutylene - containing polyethylene, polypropylene or polystyrene. However, it is

permissible to employ other suitable thermoplastic synthetic resins, for example, polyvinyl chloride. Also, if required, colouring agents, pigments, etc. may be added to the synthetic resin.

The hydrocarbons suitable for use in the invention generally include aliphatic hydrocarbons such as methane, ethane, propane, and butane used separately or in a mixture of two or more thereof. However, it is possible to use other suitable hydrocarbons like halogenated olefins, for example, difluorochloromethane.

An embodiment of the present invention will now be described by reference to the appended drawing. A raw synthetic resin feed hopper 106 and a pressure-resistant feed hopper 108 are both initially maintained at atmospheric pressure, when valves 105 are kept closed. Pellets or powders 112 of a synthetic resin stored in the feed hopper 106 are allowed to fall by gravity into the pressure-resistant feed hopper 108 through a pressure-resistant ball valve 107. The feed hopper 108 is then evacuated with the pressure-resistant ball valve 107 closed and another pressure-resistant ball valve 109 opened which leads to a vacuum pump (not shown). With the pressure-resistant ball valve 109 then closed, the pressure of the hydrocarbon which is under pressure in a bomb 101 is applied to the pressure-resistant feed hopper 108 and also to another pressure-resistant feed hopper 111 thus preserving the same pressure in both hopper 108 and hopper 111.

The application of the hydrocarbon pressure to the pressure-resistant hoppers 108 and 111 is carried out by introduction under pressure of the hydrocarbon stored in a bomb 101 into the hoppers 108 and 111 through a flow rate control valve 102, flow meter 103, pressure gauge 104 and valves 105, 105. Next, a pressure- resistant valve 110 is opened to allow the synthetic resin 112 stored in the pressure-resistant hopper 108 to fall by gravity into the pressure-resistant hopper 111. Thus the synthetic resin and hydrocarbon are continuously supplied to the pressure-resistant hopper 111 so as to be introduced into an extruder. The hydrocarbon in the pressure-resistant hopped 111 is always subjected to the required pressure by means of the high-pressure hydrocarbon gas supplying section 101 to 105. In this case, the pressurised hydrocarbon remains in a liquid or gaseous state, but usually in a liquid state. Thus, the synthetic resin and hydrocarbon introduced into the extruder through the pressure-resistant successive raw material feed apparatus 101 to 111 are heated and mixed in the screw section 113 of the extruder. The synthetic resin begins to be melted in a first low temperature region of the extruder which is maintained at a temperature T_1 slightly higher than its melting temperature. At this time, the surfaces of the synthetic resin particles are fused together thereby effectively to occlude the hydrocarbon present in the interstices between the particles of the synthetic resin. The partly melted synthetic resin occluding the hydrocarbon is transferred in succession to two regions respectively maintained at temperatures T_2 and T_3 higher than T_1 of the first region by the screw operated by a driving means 115. During transit, the mass is uniformly melted and mixed to dissolve the hydrocarbon content, and extruded through the die 116 of the cross-head 114 maintained at a temperature T_4.

Electric wiring 117 is caused to pass through the die 116 from a wiring feeder 118, so that the molten synthetic resin material extruded from the die 116 is immediately coated on the surface of the wiring. At this time the hydrocarbon dissolved in the molten synthetic resin rapidly vapourises in the molten synthetic resin due to a sharp drop in the external pressure occurring when the resin is extruded out of the die 116, thereby to form a large number of fine cells in the resin. In this case, the cooling effect resulting from the vapourisation of the dissolved hydrocarbon immediately causes the molten resin in contact with the cells to rise in viscosity, so that the cells created are fixed in the resin, thereby to produce electric wiring 119 insulated with a foamed coating. The number and size of the cells to be generated in the foamed coating are controlled by the amount of hydrocarbon supplied that is, by the pressure of the hydrocarbon, temperature of the screw section 113 and extruding speed, but can be further closely controlled by the temperatuure T_5 of an auxiliary thermal forming apparatus 120 provided, if required, in the vicinity of the cross-head 114.

As mentioned above, the apparatus described can easily manufacture electric wiring insulated with a coating of highly expanded synthetic resin consisting of fine separate cells. The time required for the molten synthetic resin to pass through the aforementioned process, namely, the process of expansion and coating after being extruded from the die is only of the order of one-hundredth of a second in the case of the following examples, that is, where a low density polyethylene-propane system is employed. Therefore, the foaming operation does not constituute a rate-determining step even when coated wiring is manufactured at a high speed of more than 1000 metres per minute.

Example 1

The thermoplastic synthetic resin used consisted of low density polyethylene having

a melt index of 1.2 and a density of 0.920, and the hydrocarbon used consisted of propane. Both materials were simultaneously introduced into the pressure-resistant hopper 111 in the aforesaid manner at a propane pressure of 15 Kg/cm² (at room temperature). The various regions of the extruder were heated as follows:

First region temperature (T_1) 195°C.
Second region temperature (T_2) 235°C.
Third region temperature (T_3) 260°C.
Temperature of cross-head and die (T_4) 270°C.

The conductor (copper) of 0.4 mm in diameter was preheated to about 100°C. The wiring was taken up at a speed of 600 meters per minute. After passing through the die, the coated wiring was cooled with water to 18°C. The layer of a foamed body coated on the wiring was about 150 microns thick, and the cells included therein were 20 to 30 microns in diameter and presented a satisfactory distribution. The foamed coating had a degree of expansion of about 60 per cent (The expansion "degree of expansion", as used herein, means the percentage total volume of cells relative to the volume of the entire foamed body), an apparent density of 0.368 and a dielectric constant of 1.4.

When the hydrocarbon pressure was changed to 12 and 18 Kg/cm² the expansion degrees of the foamed coating were about 50 and 80 per cent, respectively. In this case the dielectric constants of the foamed body were 1.5 and 1.2, respectively.

Example 2

Extrusion and foaming were carried out under the same conditions as in Example 1, excepting that the synthetic resin used consisted of low density polyethylene having a melt index of 0.3 and density of 0.920 and that the various parts of the extruder were heated as follows:

First region temperature (T_1) 200°C.
Second region temperature (T_2) 245°C.
Third region temperature (T_3) 270°C.
Temperature of cross-head and die (T_4) 275°C.

The layer of a foamed body coated on the wiring was about 150 microns thick, and the cells contained therein were 20 to 30 microns in diameter and well distributed. The foamed coating had a degree of expansion of about 60 per cent.

WHAT WE CLAIM IS:—

1. A method for preparing foamed synthetic resin insulated wiring which comprises supplying a thermoplastic synthetic resin and normally gaseous hydrocarbon soluble therein to an extruder in an atmosphere of said hydrocarbon which is at a pressure large compared with normal atmospheric pressure, heating, melting and mixing the charged materials in the extruder, and extruding the molten resin in which the hydrocarbon is uniformly dissolved, thereby to coat the surface of electric wiring with a foamed synthetic resin.

2. A method according to claim 1 wherein the foamed body coated on the wiring is further subjected to auxiliary thermal forming.

3. A method according to claim 1 or claim 2 wherein the hydrocarbon is methane, ethane, propane, butane, difluorochloromethane or a mixture of two or more thereof.

4. A method according to claim 1 or claim 2 wherein the thermoplastic synthetic resin is polyethylene, polypropylene, polystyrene, polyvinyl chloride or a mixture of polyethylene and polyisobutylene.

5. An apparatus for preparing foamed synthetic resin insuluated wiring which comprises an extruder consisting of a screw section, a driving source for driving the screw of said screw section and a cross-head directly connected to said screw section and containing a die, means for introducing a thermoplastic synthetic resin and a hydrocarbon into the extruder at a pressure large compared with normal atmospheric pressure under a condition shut off from the open air, and means for feeding electric wiring to the die of the extruder.

6. An apparatus according to claim 5 wherein there is further provided means for subjecting the foamed body coated on the wiring to auxiliary thermal forming.

7. A method for preparing foamed synthetic resin insulated wiring substantially as herein described with reference to the accompanying drawing.

8. An apparatus for preparing foamed synthetic resin insulated wiring substantially as herein described with reference to the accompanying drawing.

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1 SHEET
This drawing is a reproduction of the Original on a reduced scale.